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Integrated Systems Engineering and Test & Evaluation

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AIR FORCE FLIGHT TEST CENTER
EDWARDS AFB, CA

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Presentation given at the AF Systems Engineering Conference, Dayton OH, 16-17 August 2011. Part of a breakout session chaired by Ms Eileen Bjorkman. Discussion links the systems engineering process used in a program to help manage risk levels with the test activities performed to verify system performance.

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Systems Engineering, Test and Evaluation, Test and Evaluation Master Plan (TEMP)

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Integrated Systems Engineering and Test & Evaluation

U.S. AIR FORCE

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Overview

- Purpose
  - Discuss how integrating SE and T&E can help a program manage technical risk

- Outline
  - Common Definitions and Process Integration
  - Critical Technical Parameter
  - TEMP Risk Matrix
  - Determining Risk to Program

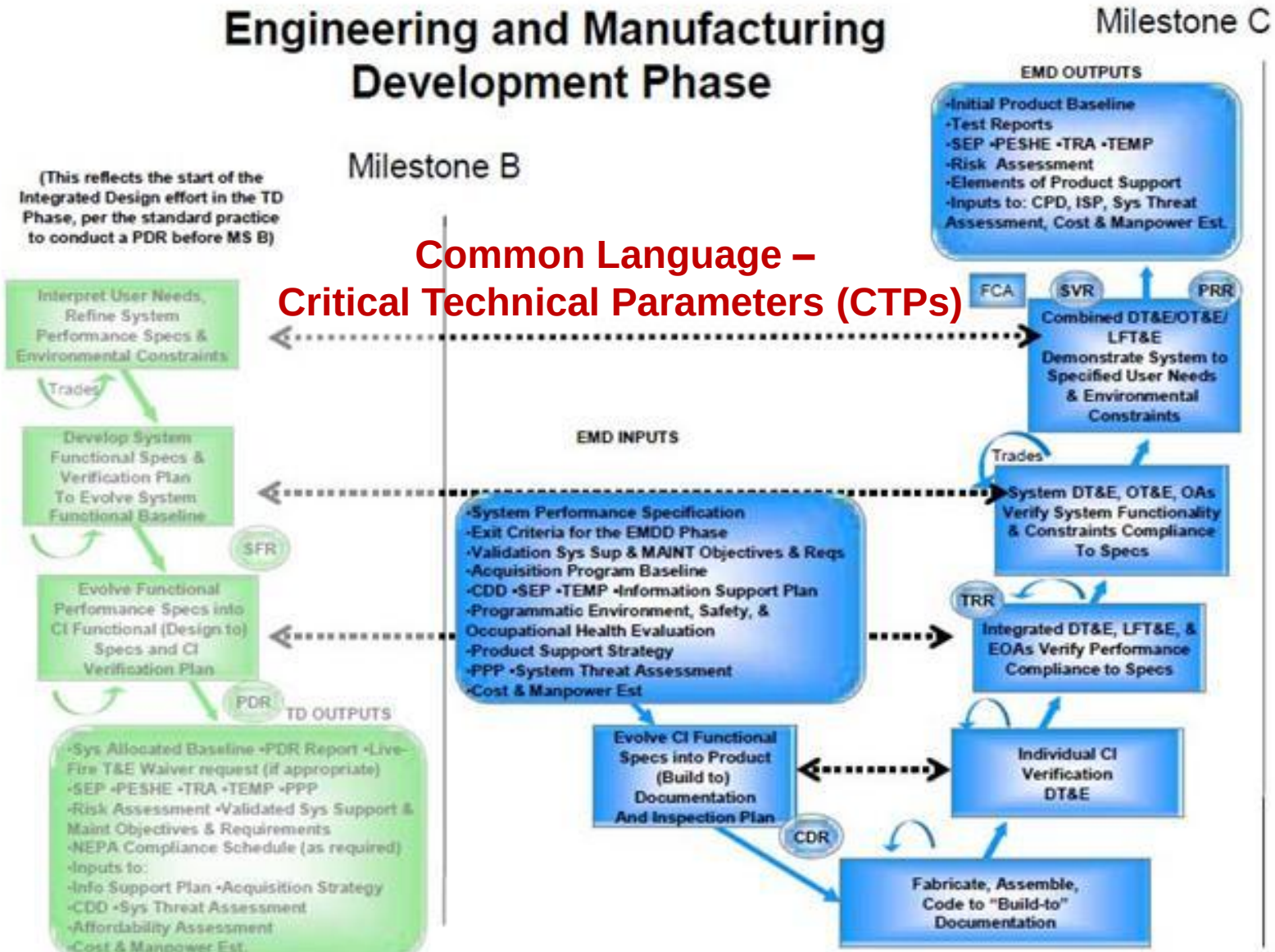
Definitions

- **Systems Engineering Definition**
  - *For DoD, systems engineering is the set of overarching processes that a programs team applies to develop an operationally effective and suitable system from a stated capability need. Systems engineering processes apply across the acquisition life cycle (adapted to each phase) and serve as a mechanism for integrating capability needs, design considerations, design constraints, and risk; as well as limitations imposed by technology, budget, and schedule. The systems engineering processes should be applied during concept definition and then continuously throughout the life cycle.*
    - » **Defense Acquisition Guidebook (DAG), Section 4.0.2**

- **Test & Evaluation Purpose**
  - *The fundamental purpose of T&E is to provide knowledge to assist in managing the risks involved in developing, producing, operating and sustaining systems and capabilities. T&E provides knowledge of system capabilities and limitations to the acquisition community for use in improving the system performance and the user community for optimizing system use and sustainment in operations. T&E enables the acquisition community to learn about limitations (technical or operational) of the system under development, so that they can be resolved prior to production and deployment.*
  - **Developmental Test and Evaluation (DT&E) supports the following**
    - *The systems engineering process to include providing information about risk and risk mitigation;*
    - *Assessing the attainment of technical performance parameters;*
    - *Providing empirical data to validate models and simulations; and*
    - *Information to support periodic technical performance and system maturity evaluations.*
      - » **DAG, Section 9.1**

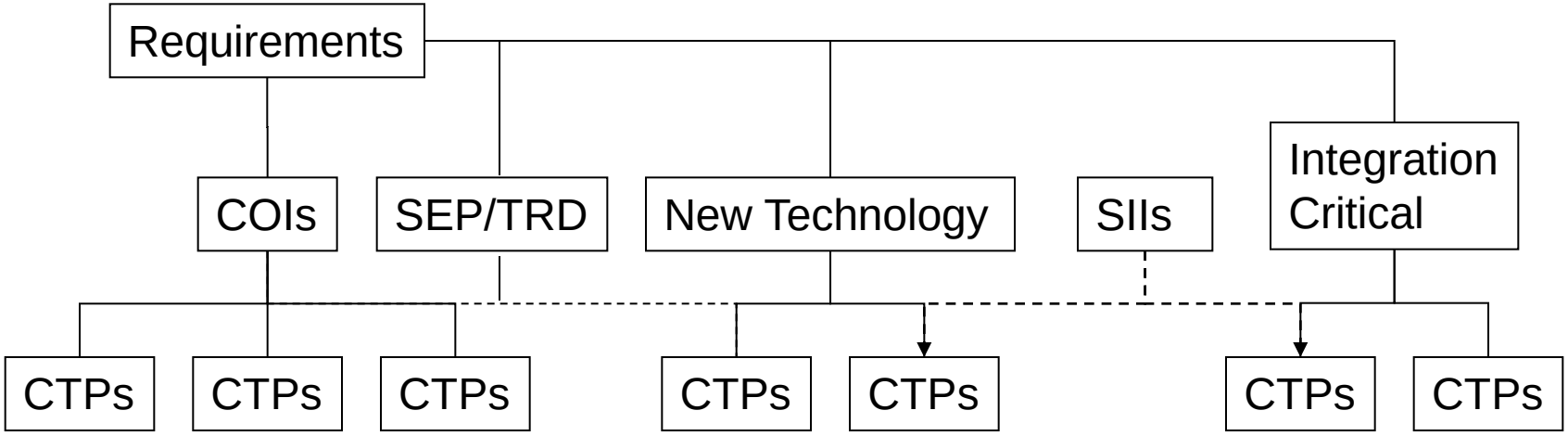
- **Critical technical parameters:**
  - Measurable critical system characteristics that, when achieved, allow the attainment of desired operational performance capabilities. They are not user requirements. Rather, they are technical measures derived from desired user capabilities. Failure to achieve a critical technical parameter should be considered a reliable indicator that the system is behind in the planned development schedule or will likely not achieve an operational requirement. Limit the list of critical technical parameters to those that support critical operational issues. The system specification is usually a good reference for the identification of critical technical parameters.
    - » **TEMP Review Checklist**

Link Between Requirements and Test Activities



Source: DAG Section 4.3.3.3

Conceptual Model of CTP Development



Provider	From Which we Derive CTPs
AFOTEC and/or MAJCOM	**Critical Operational Issues (COIs)**
Policy	**Special Interest Items (SIIs)**
Technology	**Risk Areas from either New Technology or New Application of Technology (TRD, SRD, SEP)**
MAJCOM Requirements	**Why pursue now? Any KPPs, KSAs defined in CDD. Is there a specific enabling technology breakthrough**
Implied Essential Characteristics	**Standard T&E Capabilities**

Linking CTPs into TEMP

	Test Process								
	CT Form/Fit/ Function	**CT** Component Testing	**M&S**	**SIL**	**HITL**	**ISTF**	**OAR**	**OT OAR**	**Total**
CTP Why is it a CTP? linked to what source (COI, SII, KPP, etc.)			$ Applied? Where / Who will do it? Risk Impact? Required? Dependencies?						Total $ Test articles Residual Risk
CTP									
CTP									
CTP									
CTP									
…									
Totals									Overall Total $ & test articles

Backup Data for CTP Blocks

- For Each CTP line
  - Why is it a CTP
  - What is the approach to addressing the CTP and why
    - Need to address programmatic constraints
    - Technical analysis
    - Trade-offs across blocks within the same row
- For Each block
  - Basis for estimate of $ and risk mitigation
  - Discussion of why “the who will do it” is proposed
  - Specifics of what each block is (ex. Specific HWIL capability)
  - Issues to be addressed by program
    - When
    - Duration
    - Long lead time
    - Test assets required
    - Dependencies between tests
    - Dependencies for key program events/milestones

Notional Risk Criteria

- Need to “quantify” the risk reduction associated with test activities in evaluating CTPs
  - Directly links T&E with risk reduction to important technical issues in the program

- Concept
  - Parallel TRL approach – Use 1-9 framework, higher number, more confidence
    - Potential name – RCL – requirement confidence level
    - Similar to cooper-harper approach using:
      - How representative is the test article? (integration, full-system, component, breadboard, etc.)
      - How representative is the test environment? Laboratory, environmental diversity, threat, etc.?)
      - Level of statistical significance (single event, # of independent/dependent variables, variable sensitivity, etc.)

- Concept Assessments
  - RCL 1 – have no confidence that this CTP will be satisfied (no component or higher level system/integrated testing conducted)
  - RCL 9 – have complete confidence that this CTP is satisfied (have demonstrated this w/ production representative full-up-system in operationally relevant environment with sufficient statistical basis to provide/establish confidence.

Example Confidence Level Criteria

- Test article representative?
  - Score of 1 - Item being evaluated (components or subsystems) is breadboard or unconstrained prototype,
  - Score of 2 - Item being evaluated is pre-production, hardware/software still being worked,
  - Score of 3 - Items being evaluated are production items
- Test environment representative?
  - Score of 1 - Laboratory,
  - Score of 2 - ISTF,
  - Score of 3 - OAR w/ full operational threats/loads
- Level of statistical significance?
  - Score of 1 - It works occasionally,
  - Score of 2 - It worked most of the times we tried it,
  - Score of 3 - It worked every time we tried it and we've taken enough test data to demonstrate required performance at required confidence level

Notional CTP in TEMP

	Test Process								
	CT Form/Fit/ Function	**CT Component Testing**	**M&S**	**SIL**	**HITL**	**ISTF**	**DT OAR**	**OT OAR**	**Total**
CTP 1-1 ASIP must correctly identify all threat catalog signals, 99.7% accuracy w/in 500 msec at processor saturation COI-1 MOEs: 1-1, 1-1-1, 1-1-2 KPPs: 1-1-1, 1-1-2, both classified	KTR will perform FFF testing to validate that each component of sensor / processing system meets requirement of each candidate host platform See classified annex for specific applications / limits	KTR will validate processing speeds, catalog accuracy, classification & lookup algorithms Validates that basic assumptions are correct Cost included in baseline SDD contract **RCL - 1**		KTR will verify performance of algorithms in SIL prior to delivery of first article for HITL test Use SIL at Raytheon to speed up test, analyze, fix cycle SIL must reach IOC by Jun 08 to meet rqmt **RCL - 3**	BAF Labs– exercise threat catalog of signals through sensors to processer, to coded output signal – establish performance baseline BAF – Edwards AFB, 4 weeks – with sensors, cabling, processors and coder/transmitter - $200K, KTR lead testing **RCL - 4**	With system installed in parent vehicle, in BAF, repeat HITL testing – baseline performance Test, analyze, fix opportunity BAF – EAFB 6 weeks - $400K, production parent platform, installed sensors, system AF/DT lead test **RCL - 7**		On NTTR – with in excess of 100 threat emitters, validate performance meets requirement Incl – blinking, jamming, and cooperative engagement tactics NTTR – OT lead testing, cost in baseline program – funded at $6M total – 12 weeks **RCL - 8**	Total $: $6.6M Test articles: 2 pre-prod ship sets, 2 production ship sets, Plus parent platform (and backup) available for BAF and OT Residual Risk: Small – achieve statistical significance of performance in BAF, but equivalent testing in OT is cost prohibitive. OT will spot check
CTP									
…	Same process for each CTP								
Totals									**Overall Total $ & test articles**

QUESTIONS